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Procedia - Social and Behavioral Sciences 65 (2012) 14 – 19

Procedia
Social and Behavioral Sciences

International Congress on Interdisciplinary Business and Social Science 2012

(ICIBSoS 2012)

Asia-Pacific Currency Options Pricing Analysis

Ariful Hoque

Murdoch University, Perth, Australia

Abstract

During the Global Financial Crisis (GFC), the Asia-Pacific currencies, the Australian dollar (AUD) and the Japanese yen (JPY), behaved differently. The AUD depreciated and the JPY appreciated by 30% and 17%, respectively, against the US dollar. This contradictory price movement increased the demand for AUD and JPY options for use as speculations and hedging tools. This was a concern for the participants in the foreign exchange (FX) market, specifically for hedgers, who suffer financial losses when options are mispriced. This study, therefore, examines the post GFC Asia-Pacific currency options market efficiency to ensure that the AUD and JPY options are priced accurately. We develop a new econometric method with the idea that the call and put hold the price where it should be if their price difference is equal to the return from their moneyness. The overall test results suggest that, on average, the Asia-Pacific currency options market is efficient, thus suggesting that the underlying AUD and JPY currency markets are relatively stable. Our findings imply that European investors consider the AUD and JPY as safe-haven currencies in the post GFC European debt crisis period.

Selection and peer-review under responsibility of JIBES University, Jakarta

Keywords: Global Financial Crisis; Asia-Pacific Currency Options; Put-Call Parity; Serial Correlation; ARCH; GARCH; Wald Test

1. Introduction

The Australian Bureau of Statistics (2009) stated that the Australian dollar (AUD) depreciated against the US dollar (USD) rapidly and sizeably as the global financial crisis (GFC) intensified, declining by over 30% from its July 2008 peak. Kawai and Takagi (2009) reported in the Asian Development Bank Institute Working Paper that the nominal value of the Japanese yen (JPY) had appreciated by 17% against the USD from September 2008 to January 2009. The speculators took advantage of the opposite nature of the performances of the AUD and JPY against the USD, by holding an AUD and JPY options contract and insisting that hedgers hold AUD and JPY options to manage their financial risk. However, the high demand for AUD and JPY options increased the possibility of mispricing. This study, therefore, analyses the post GFC Asia-Pacific currency options market efficiency to ensure that AUD and JPY options are priced accurately. The put-call parity (PCP) relationship is well-

1877-0428
Selection and peer-review under responsibility of JIBES University, Jakarta
doi:10.1016/j.sbspro.2012.11.084

accepted to conclude whether the option market is efficient, thereby leading to the correct pricing of options. The PCP is a no-arbitrage relationship which must be satisfied to prevent arbitrage profit opportunity. Giddy (1983) and Grabbe (1983) were among the first to design the PCP relationship for foreign currency options using the PCP theorem developed by Stoll (1969) for equity. To examine the possibility of arbitrage profit opportunity, several studies have conducted PCP tests without allowing transaction costs (see, for example, Trippi, 1977; Chiras and Manaster, 1978; Shastri and Tandon, 1985; Bodurtha and Courtadon, 1986). In general, the PCP test results in these studies did not support that the options were priced efficiently.

A systematic treatment of the transaction costs (TC) facing traders in the organised options market can be seen in the work of Phillips and Smith (1980). They considered explicit costs, in the form of commission and other fees, and implicit costs, such as bid-ask spreads, in options pricing. They found that the larger the TC are, the wider is the band within which the options price can swing without creating arbitrage opportunities. Keim (1989) and Yadav and Pope (1990) took into account one per cent as an average bid-ask spread in their PCP tests. Subsequently, Puttonen (1993) considered two per cent of the bid-ask spread for the Helsinki Stock Exchange. Nisbet (1992) identified that the PCP violation in the presence of only bid-ask spreads almost disappeared when commission was included in the bid-ask spreads. Chateauneuf et al. (1996) pointed out that bid-ask spreads differ from the traditional formalization of proportional TC. Torricelli (2005) suggested that other types of costs (e.g. clearing fees, short selling costs) in addition to bid-ask spreads should be considered and that the commission should be more precise about the TC.

For the German mark options market efficiency, El-Mekkaoui and Flood (1998) conducted PCP tests in the presence of transaction costs using intra-daily data. They used 0.0625 per cent TC, as Surajaras and Sweeney (1992) suggested in their study. However, Rhee and Chang (1992) used 0.0409 per cent TC for the Deutsche Mark (DEM). Mittnik and Rieken (2000) analysed the informational efficiency of the Garman DAX-index options market in the presence of TC. In their study, a fee of DEM 0.40 per contract and 0.1 per cent of the index value represented the trading costs.

After reviewing the literature, we find several weaknesses in the PCP tests for options market efficiency to confirm options pricing accuracy: (1) insignificant arbitrage profit due to PCP violation also indicates that the options market is not efficient; (2) significant arbitrage profit becomes insignificant in the presence of TC; and (3) standard TC is not easy to determine, since it varies across markets and currencies. This study provides an econometric approach where PCP violation either in the presence or absence of TC and the issues of TC estimation are not included, and it overcomes the pitfalls of the PCP test. The proposed model is developed based on the options price and its moneyness. The overall test results confirm that, on average, the Asia-Pacific currency options are priced efficiently. The paper is organized as follows. Section 2 presents the research methodology and data. Section 3 discusses the regression results of the empirical analysis. Finally, section 4 concludes the paper.

2. Methodology and Data

The methodology in this section is designed based on the relationship between options prices and their moneyness. The idea of the new approach is that the call and put hold the price as it should be if their price difference is equal to the return from their moneyness. Options in-the-money (ITM) and out-of-the-money (OTM) moneyness describe profit and loss, respectively, for their immediate exercise. Consequently, the call (put) option should be sold at a higher price than that of the put (call) option when call (put) and put (call) are traded ITM and OTM, respectively. Using this options market trading mechanism, we have developed an econometric model as in equation (1):

$$C_t - P_t = \alpha_0 + \alpha_1 LOG\left(\frac{S_t}{X_t e^{-RT}}\right) + \varepsilon_t \quad (1)$$

where, C, P, S, X, R and T represent call price, put price, spot price, strike price, domestic risk-free interest rate and time to maturity, respectively. Equation (1) shows that the call and put price difference is related to their moneyness return. Now, we consider that $(C_t - P_t) = Y_t$ and $LOG\left(\frac{S_t}{X_t e^{-RT}}\right) = X_t$ and rearrange equation (1) to develop the regression equation (2) as follows:

$$Y_t = \alpha_0 + \alpha_1 X_t + \varepsilon_t. \qquad (2)$$

Under the null hypothesis, the coefficients α_0 and α_1 in equation (2) should be 0 and 1, respectively, to conclude that the call and put options are priced efficiently. We address the unit root issue for Y_t and X_t series, as Hoque et al. (2008) found that strike price, spot price and interest rate are non-stationary; otherwise, the OLS estimates are likely to be spurious. To further accommodate potential autocorrelation and conditional heteroskedasticity, equation (2) needs to be augmented as shown in equation (3):

$$Y_t = \alpha_0 + \alpha_1 X_t + \sum_i^p \emptyset_i Y_{t-i} + \sum_i^q \theta_i \varepsilon_{t-i} + \varepsilon_t \qquad (3)$$

Without accommodating the serial correlation and heteroskedasticity, the results would lead to biased and inconsistent inferences for α_0 and α_1. The choice of the lag order, p and q, will be driven by the results of the diagnostic tests and various information criteria. In the presence of GARCH(r,s) error in equation (3), following Bollerlev (1986), ε_t can be decomposed as follows:

$$\varepsilon_t = \rho_t \sqrt{h_t}\ ;\quad \rho_t \approx iid(0,1);\quad h_t = \omega + \sum_{i=1}^{r} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{s} \beta_i h_{t-i}\,, \qquad (4)$$

with the conditions $\omega > 0$, $\alpha_i \geq 0$ and $\beta_i \geq 0$ to ensure that $h_t > 0$. Once the presence of GARCH error is confirmed by the LM test of Bollerslev (1986), the lag order, r and s, will be determined by further diagnostic tests and various information criteria as suggested in Bollerslev (1986).

The options pricing analysis was conducted for options on the AUD and JPY, two Asia-Pacific currencies. This study includes the put-call pairs of the sample currencies from 26 June 2011 to 25 May 2012. The contract size is 10,000 and 100,000 for the AUD and JPY, respectively. These options mature on the third Friday of each month. The data set also consists of the daily closing spot price and the daily USD risk-free interest rate for the sample period. All data sets are obtained from Datastream. The sample period is less than a year because Options Pricing Authority data is available from 26 June 2012 in the Datastream.

3. Empirical Analysis

In this section, the econometric analysis is conducted by estimating equation (2), the relationship between options price and their moneyness. Since the Y and X data series in equation (2) fail to reject that there is no unit root under the Augmented Dickey-Fuller and Phillips-Perron (see Philips and Perron, 1988) tests, the regression analysis is performed for the first difference of the Y and X series, and the results are given in Table 1. To detect the possible presence of serial correlation problems and ARCH effects, Lagrange multiplier (LM) tests are employed. For each currency, the regression analysis is performed for three sets of data with different strike prices. Panels A and B provide the regression results for options on the AUD and JPY, respectively. In columns 5 and 6, the P-value of the F-statistic under the LM test is zero for all currencies, indicating that the null hypothesis of serial correlation and the ARCH in the residual are rejected. The least squares (LS) regression standard errors are invalid in the presence of serial correlation and should not be used to infer the parameters. The ARCH effects may result in the loss of efficiency of the LS regression. Efficiency is desirable because when greater efficiency is associated with an estimated process, stronger statistical statements can be made about the estimated parameter.

Table 1: Regression Test Without Accommodation of Serial Correlation and ARCH Effects

Strike price	Intercept (std. error)	Slope (std. error)	Serial Correlation Test F-statistic (P-value)	ARCH Test F-statistic (P-value)
Panel A: Australian Dollar				
100	0.00023	0.7411	72.5454	157.6122
	(0.00035)	(0.0380)	(0.0000)	(0.0000)
105	0.00024	0.7370	69.1736	148.8573
	(0.00035)	(0.0379)	(0.0000)	(0.0000)
110	0.00024	0.74030	63.5984	136.0320
	(0.0004)	(0.0380)	(0.0000)	(0.0000)
Panel B: Japanese Yen				
110	0.00019	1.0892	42.3373	73.8181
	(0.00022)	(0.0425)	(0.0000)	(0.0000)
120	0.00017	1.0016	47.2451	66.0789
	(0.00022)	(0.0237)	(0.0000)	(0.0000)
130	0.00016	0.9324	35.8263	56.9469
	(9.01E-05)	(0.0171)	(0.0000)	(0.0000)

To accommodate the serial correlation and ARCH effects, equation (2) is re-estimated by employing equations (3) and (4), respectively. The results are summarized in Table 2, which is structured the same as Table 1. Thus, panels A and B provide the AUD and JPY options regression results, respectively, for three different strike price data sets. In columns 5 and 6, the P-values for the F-statistic under the LM tests indicate that the data fails to reject the null hypothesis of no serial correlation and the ARCH in the residual for all sample currencies. Next, we examine the values of the intercepts as reported in column 2. The null hypothesis, H_0: $\alpha_0 = 0$, cannot be rejected at any standard significance level, indicating that the intercepts are not statistically different from 0 in all cases except for the JPY strike price 110. However, the values of the intercept in column 2 are negligible. Finally, we look at the slope coefficient (α_1) with the standard error (std. error) in the parentheses as reported in column 3 of Table 2. The estimates of α_1 are statistically different from 0 in all cases.

Table 2: Regression Test With Accommodation of Serial Correlation and ARCH Effects

Strike price	Intercept(std. error)	Slope (std. error)	Serial Correlation Test		Heteroskedasticity Test	
			ARMA	F-stat (P-value)	GARCH	F-stat (P-value)
Panel A: Australian Dollar						
100	0.00033	0.9823	(2,2)	0.8232	(2,1)	0.0010
	(1.04E-05)	(0.0089)		(0.4403)		(0.9747)
105	0.00032	0.9810	(2,2)	0.6748	(6,0)	0.7622
	(7.99E-06)	(0.0076)		(0.5102)		(0.7827)
110	0.00033	0.9797	(3,3)	0.1676	(6,0)	0.02271
	(1.02E-05)	(0.0091)		(0.8458)		(0.8803)
Panel B: Japanese Yen						
110	4.72E-05	1.0776	(1,1)	0.5682	(2,2)	0.5843
	(0.00023)	(0.0438)		(0.5673)		(0.4454)
120	0.00016	1.0260	(2,2)	0.0335	(2,0)	0.0413
	(4.01E-05)	(0.0135)		(0.9672)		(0.8392)
130	0.00019	0.9818	(2,2)	0.1717	(1,1)	0.2105
	(1.87E-05)	(0.0096)		(0.8423)		(0.6468)

The null hypothesis, H_0: $\alpha_1 = 1$, tests results are given in Table 3. The regression results for slopes (α_1) from Table 2 are reproduced in Table 3 with the standard errors under T-tests. The standard errors are given in parentheses next to the estimated coefficients. The high values of R^2 in the last column of Table 3 indicate a good fit of the regression line for all data sets of both currency options. In column 2, the T-test reveals that the null hypothesis, $H_0: \alpha_1 = 1$, cannot be rejected at any standard level of significance.

To obtain a precise significance level, a Wald test is conducted, and the results are presented in column 3. Under the Wald test, the P-values next to the F-statistic in parentheses indicate that the null hypothesis, H_0: $\alpha_1 = 1$, cannot be rejected at the 5, 1 and 3 per cent significance levels for the AUD options strike price 100, 105 and 110, respectively. For the JPY, the null hypothesis, H_0: $\alpha_1 = 1$, cannot be rejected at the 8, 5 and 6 per cent significance levels for strike price 110, 120 and 130, respectively. Since the higher significance level narrows the band to reject the null hypothesis, the JPY options are priced more efficiently than the AUD options.

Table 3: Analysis of Equality of Slope Coefficient to 1

Strike price	T-tests Coefficient (Std. error)	Wald tests F-statistic (P-value)	R^2
Panel A: Australian Dollar			
100	0.9823 (0.0089)	3.92244 (0.0488)	0.7746
105	0.9810 (0.0076)	6.3190 (0.0126)	0.7694
110	0.9797 (0.0091)	4.9867 (0.0265)	0.7771
Panel B: Japanese Yen			
110	1.0776 (0.0438)	3.1326 (0.0780)	0.7838
120	1.0260 (0.0135)	3.7341 (0.0545)	0.9219
130	0.9818 (0.0096)	3.5601 (0.0604)	0.9478

4. Conclusion

In the GFC, the AUD and JPY performed completely differently in nature. Against the USD, the AUD depreciated by 30%, whereas the JPY appreciated by 17%. The speculators took advantage of this opposite price movement by holding an AUD and JPY options contract. It was also a concern for those participating in the foreign exchange (FX) market, particularly for the hedgers interested in the Asia-Pacific options market to manage their financial risk due to the FX exposure. The heavy demand for AUD and JPY options increased the possibility of them being mispriced. This study, therefore, examined the post GFC Asia-Pacific currency options price accuracy to convey an important message to foreign investors that after the GFC, the currency options market functioned efficiently in the Australian and Japanese financial markets.

In this study, we developed a new approach which is not only simple, but also overcomes the following two major drawbacks of standard PCP tests for options pricing efficiency: (1) it is critical to determine the attractive arbitrage profit amount due to the violation of the PCP relationship, and (2) it is a challenging issue to estimate the standard transaction costs. The econometric model was developed based on the relationship between the options price and its moneyness. If options provide profit and loss for their immediate exercise, the options moneyness is described as ITM and OTM, respectively. In this instance, the call (put) option should be sold at a higher price than that of the put (call) option if the call (put) and put (call) are traded ITM and OTM, respectively. Our approach mainly uses this options market trading mechanism to examine whether the difference of the call and put options is equal to their moneyness return. If the call and put price difference and return are equal, we can conclude that the options are priced efficiently.

To justify our conclusion, we conducted a regression analysis by taking the unit root issue into account; otherwise, the OLS estimates are likely to be spurious. We also accommodated the potential autocorrelation and conditional heteroskedasticity to obtain unbiased and consistent inferences for the intercept and slope. Further, the Wald test was employed to obtain a precise significance level for the slope, which was equal to 1 statistically. For each sample currency, the regression analysis was performed for three sets of data with different strike prices. The Wald test results for the AUD options show that the slope is equal to 1 at the 5, 1 and 3 per cent levels of significance for strike price 100, 105 and 110, respectively. Similarly, for the JPY options strike price 110, 120 and 130, the slope is equal to 1 at the 8, 5 and 6 per cent levels of significance, respectively. The overall empirical analysis indicates that, on average, the Asia-Pacific options are well-priced. Further, the Asia-Pacific currency options market efficiency also indicates that the underlying AUD and JPY currency markets are relatively less volatile. As an implication of this study, we find that the recent European Debt Crisis has pushed investors to choose AUD and JPY as safe-haven currencies for their investments.

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